No. 73.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE PLUM CURCULIO.

(*Conotrachelus nenuphar* Herbst.)

By FRED JOHNSON and A. A. GIRAULT,

Engaged in Deciduous-Fruit Insect Investigations.

INTRODUCTION.

The small, crescent-shaped punctures so commonly found on plums and other stone fruits in orchards east of the Rocky Mountains are made by a small snout-beetle of rough sculpture, known as the plum curculio. These beetles issue from their winter quarters about the time the trees are in bloom, and feed on the tender foliage, buds, and blossoms. Later they attack the newly set fruit, cutting small circular holes through the skin in feeding, while the females, in the operation of egg laying, make the crescentic cuts so characteristic of this species. The egg, deposited under the skin of the fruit, soon hatches into a very small whitish larva or grub, which makes its way into the flesh of the fruit. Here it feeds greedily and grows rapidly, becoming, in the course of a fortnight, the fat, dirty white "worm" so well known among fruit growers.

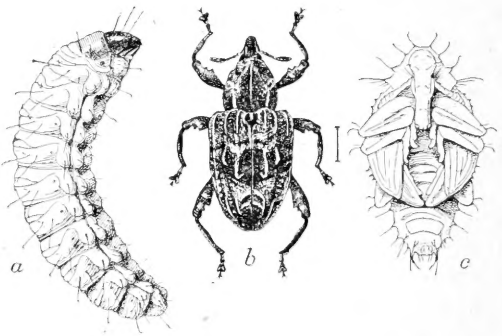

FIG. 1.—The plum curculio (*Conotrachelus nenuphar*): *a*, larva; *b*, adult; *c*, pupa. Much enlarged (hair line to right of *b* indicates natural length of adult). (From Chittenden.)

The plum curculio is a native of North America and for more than one hundred and fifty years has been known as an enemy of stone fruits. Our early horticultural literature abounds with references to its depredations. In more recent times the great increase in plantings of fruits, brought about to supply the increased demand, has permitted it to become much more abundant than formerly, and the plum curculio constitutes, at the present time, one of the most serious insect enemies of orchard crops.

This species is quite generally distributed over the United States eastward of about the one hundredth meridian, its range extending from southern Canada to Florida and Texas. Westward of the States

bordering the Mississippi River it rapidly loses its importance as a pest, owing probably to the more arid condition of the climate.

LIFE HISTORY AND HABITS.

Like other beetles, the plum curculio has four distinct stages in its life, namely, the egg, the larva or "worm," the pupa, and the adult or beetle. The last three stages are shown much enlarged in figure 1.

The insect passes the winter in the adult or beetle stage under accumulations of partly decayed leaves, among the closely packed dried grass of sod-covered orchards, and probably wherever suitable protection from the weather may be found. As its depredations are usually the worst in those portions of orchards which are in close proximity to woods, the beetles doubtless find the natural accumulations of rubbish in such situations very suitable places in which to pass the winter.

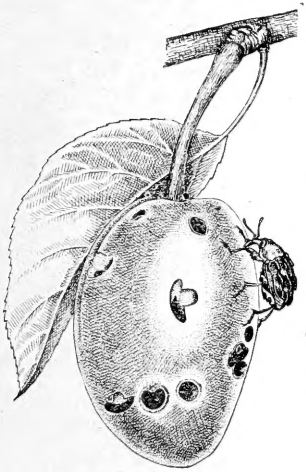

FIG. 2.—The plum curculio: Adult female on plum, showing the circular feeding punctures and the crescentic egg-laying punctures. Enlarged (original).

In Niagara County, N. Y., during the fall of 1905, numerous careful searches for beetles were made under leaves and rubbish in plum, peach, and apple orchards, and woodlots and hedgerows adjoining them. These searches did not discover any hibernating beetles except in one large apple orchard where the ground was covered with sod. Failure to find beetles in other places was probably due to the scarcity of the insect in plum and peach orchards during the preceding summer. In the sod-covered apple orchard mentioned, a total of 42 beetles was found at various times between October 14 and November 28. In every case they were beneath partly decayed leaves under apple trees and often in depressions in the soil into which the leaves were closely packed.

In the spring, when the fruit buds are unfolding, the beetles begin to emerge from their winter quarters and feed to some extent on the blossoms and tender leaves. Mating soon begins, and by the time the fruit is well set the beetles make this fruit the chief object of their attention. Figure 2 is an enlarged illustration of a young plum, showing a female beetle and the characteristic feeding and egg-laying punctures which she has been engaged, with others, in making. The circular punctures are made in feeding; the others are egg punctures.

A single egg is deposited in a puncture, although several may be placed in a single fruit. From one to eight eggs may be deposited daily by an individual female. Oviposition and feeding continue

for several weeks and in the case of the hardier individuals may extend over a period of several months. Egg laying is, however, most active during the first four or five weeks after emergence of the beetles in spring.

During recent years egg-laying records for the season, made in widely separated localities, show that the total number of eggs deposited by the female varies widely. In Maryland Professor Quaintance and Mr. R. I. Smith found that the number deposited in plums by females of longest life varied from 276 to 436. At Washington, D. C., the junior author during the past season obtained records of oviposition in plums which showed a range of from 273 to 560. A record of egg deposition in plums was also made by the senior author in western New York during the same season, and this showed a range of from 76 to 254. Professor Crandall, in Illinois, obtained records for apples showing a range of from 18 to 252 for individuals of longest life. The number of days required for the eggs to hatch varies according to temperature. Records of the past season show that at Washington, D. C., the time varies from about three to five days, whereas in western New York it varies from about four to seven days.

When the larva attains full growth, which requires some twelve to eighteen days, it bores its way out of the fruit and enters the soil. At a depth varying from one-half inch to 2 inches, rarely much deeper, it forms an earthen cell in which to pupate. The time required for the pupal stage and the emergence of the normally colored beetle is from three to four weeks. Thus the period of development from egg to adult is covered in from about five to seven weeks. Differences in weather and soil conditions, however, cause the time of emergence of the adults to vary greatly. When the soil is very dry, the beetles may remain in the pupal cell for days or even weeks after their normal period of emergence, whereas after a heavy rain they may emerge in numbers. Thus a new generation of beetles from eggs deposited early in the season appears some time before all the parent beetles have died. In fact, some of the overwintering beetles have been kept alive until late in October.

Upon emergence from the soil, beetles of the new generation almost immediately turn their attention to ungathered fruit, if this be present on the trees. In Georgia peach orchards, as observed by Mr. J. H. Beattie, of this Bureau, the beetles attack the foliage in cases where the fruit has been harvested. Prunes, plums, and peaches often suffer severely, and the injury is familiar to many orchardists as the circular punctures and pits made at the stem end of the fruits, causing the latter to rot and drop off a few days before ripening. The work of the new generation of the curculio is conspicuous on late varieties of apples also, the beetles feeding upon these until the

approach of cold weather, when they leave the trees and seek winter quarters. In orchards where sod and other conditions permit the accumulation of leaves and rubbish directly beneath the trees many beetles simply go to the ground, work beneath the leaves, and there pass the winter, and are thus near at hand to attack the fruit when it develops the following spring.

FOOD PLANTS.

The natural food plant of the plum curculio is undoubtedly the native wild plum. The curculio also feeds upon and breeds in wild crabapples, wild cherries, and haws, and is reported to breed in the persimmon. It has also been bred from a common fungous growth of plums and cherries called "black-knot" (*Plowrightia morbosa* Sacc.), though this is evidently an abnormal habit. Of the cultivated pome and stone fruits, nearly all are attacked for feeding and egg-laying purposes, including plums, peaches, cherries, nectarines, apricots, apples, and pears, but of those listed the smooth-skinned sorts, notably plums, are preferred. The beetle feeds also upon the blossoms and foliage of its various food plants, but to a much more limited extent.

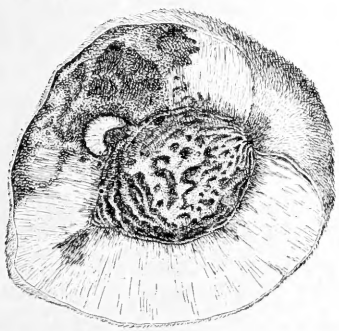

FIG. 3.—Nearly full-grown larva of the plum curculio in a ripe peach, showing injury to the interior of the fruit. Somewhat reduced (original).

CHARACTER OF INJURY.

The plum curculio is injurious in both the larval and adult stages, though it is in the adult stage that it is most harmful. The young fruit becomes badly scarred by the more or less crescentic egg punctures and pit-like feeding punctures, and in late summer and fall fruit is injured by the feeding of beetles of the new generation. The presence of the larva in the young fruit generally causes it to fall, and in cherries and nearly ripe peaches and plums in which it may develop the fruit is spoiled. (See figure 3, showing injury of this character to a ripe peach.) The character of injury varies somewhat according to the kind of fruit, and for this reason is best discussed under separate headings.

Plum.—The plum is undoubtedly the favorite food of this insect and accordingly suffers severe injury when the curculio is abundant. Eggs are deposited in the young fruit, and this may soon fall to the ground, a result of injury caused by the young larvæ. In seasons of short crops very little fruit may remain to ripen. With varieties which are inclined to overbear in seasons of very heavy crops, however, this kind of work may result in much good by thinning the

crop. As the fruit becomes larger the many egg and feeding punctures which it has received cause it to become misshapen and to exude masses of gum. When the plums become of some size and are growing rapidly, the larvæ are apparently not able to develop, but when the fruit is nearly mature and softer they are better able to survive, and thus ripe fruit on the trees is often "wormy." In certain localities late varieties are sometimes badly injured by feeding punctures of the new generation of adults.

Apple.—Curculio injury to the apple has lately been the cause of considerable complaint. It is much like that done to the plum, though the young fruit is not so likely to fall to the ground when punctured, and the larvæ are probably never able to mature in fruit which remains on the tree. The young fruit may largely outgrow the egg puncture, which may show in the ripe fruit as a brown and roughened, more or less crescentic spot which does not materially affect its value; but when badly punctured, especially by feeding of the beetles, the fruit as it grows becomes knotted and pitted. Fall and winter varieties may be seriously injured by the feeding upon the fruit of beetles of the new generation.

Peach.—On account of the thick fuzzy pubescence on the young peach, this fruit is perhaps attacked less early than is the plum, but the character of the injury is essentially the same. Many fall to the ground. Those remaining on the trees, if badly punctured, become knotty and misshapen and often exude masses of gum from the wounds. Such fruit will usually ripen prematurely. Ripe fruit which appears perfectly sound, but which contains nearly full-grown larvæ, is often found on the trees. To all appearances such fruit is in first-class condition and is thus often shipped to market.

Cherry.—In most cases infested cherries do not fall to the ground, the larvæ maturing in the fruit on the trees. Usually but a single larva is found in a fruit, and infestation is apt to go undetected.

Apricot and nectarine.—These are usually injured in much the same way as are plum and peach. Isolated trees loaded with apricots are often so badly infested that not a single fruit escapes.

Pear.—Curculio larvæ are apparently not able to develop in fruit on the trees, hence injury is confined to the egg and feeding punctures made by the adults when the pears are small. In fruit which does not fall the injury may be quite outgrown, but in cases of excessive puncturing the fruit is badly warped.

NATURAL ENEMIES.

Under the head of natural enemies are to be mentioned several parasites of the plum curculio which play a very important rôle in holding the insect in check. Perhaps the most important of these is a minute hymenopterous insect belonging to the family Mymaridæ,

which attacks the egg, although the latter is apparently well protected under the skin of the fruit. This insect is known by the scientific name *Anaphes conotracheli* Girault. It is now known to occur in Georgia, North Carolina, Virginia, Maryland, the District of Columbia, Kentucky, Connecticut, Texas, and Indian Territory, and is apparently quite abundant. According to the few observations which have thus far been made, it destroys in Maryland from 16 to 70 per cent of the eggs, and as the life cycle in June was only nine days, several generations of this parasite must successfully develop in the eggs of the plum curculio, thus increasing its efficiency.

The other parasites attack the larva or grub. They are *Sigalphus curculionis* Fitch and its variety *rufus* Riley, and *Thersilochus cono-*

FIG. 4.—Jarring for the plum curculio in a Georgia peach orchard. (Original.)

tracheli Riley. The former is of much more importance than the latter because of its greater abundance. It is a common parasite of several other coleopterous larvæ and is quite widely distributed. Limited observations indicate that this parasite destroys about 20 per cent of the larvæ of the plum curculio. *Thersilochus conotracheli* has not been met with outside of New York State, and the influence it exerts in keeping down the curculio is perhaps very small.

Besides the true parasites several predaceous beetles and ants attack and destroy the curculio larvæ as they leave the fruit to enter the soil for pupation. Their value in most cases does not equal that of the parasites.

Chickens are said to help greatly in destroying the beetles, especially in small orchards planted near the home.

PREVENTIVE MEASURES.

Although many methods have been proposed for lessening the injury of this pernicious pest, only a few have proved of real value.

Jarring.—Among these, jarring is the method which is perhaps in most general use in protecting plums and peaches, and by many orchardists it is believed to give the best results. Early observations upon the plum curculio showed that this insect has a habit of falling to the ground and "playing possum" when disturbed. A knowledge of this habit has led to the capture of the beetles on sheets held or spread beneath the trees, the trees being jarred by a sudden, forcible blow struck with a padded pole or mallet in order to dislodge the beetles.

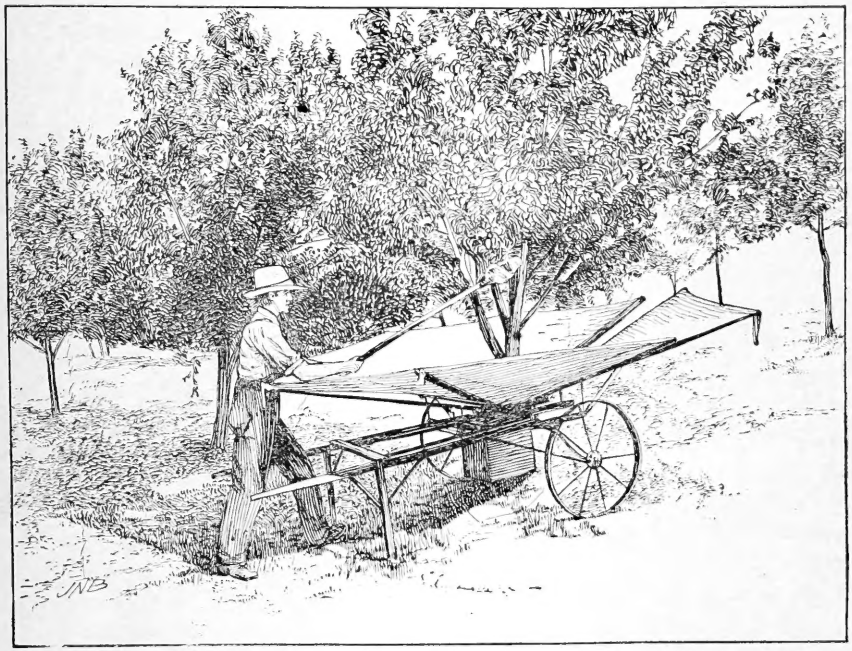

FIG. 5.—The cart catcher in use in jarring for the plum curculio. (After Slingerland.)

In the spring, about the time the calyx or "shuck" is beginning to slip off from the newly set fruit, jarring is commenced and is continued daily or as often as the weather will permit for a period of four or five weeks or until the operation ceases to yield many beetles. Jarring is best done in the early morning or late evening, for at these times the beetles are less active, drop more readily, and are not so likely to escape by flying or crawling from the sheets as they are at midday.

There are several kinds of catchers in common use by orchardists. One form is shown in figure 4 and consists of a light framework 12 feet long by 6 feet wide, over which a canvas is stretched. The jarring gang consists of five persons. Two of the frames of the dimensions given are used together, each frame being carried by a couple of women or boys, as shown in the figure. One frame is held on each side of the tree, while the fifth member of the gang, who carries a long-handled padded pole, gives the trunk of the tree a sharp, forcible blow. With this outfit a large number of trees may be jarred in a very short time. It is therefore especially suitable for work on a large scale. The curculios which fall to the sheets are collected and destroyed when the end of the row is reached, and the beneficial insects, principally ladybirds, are allowed to escape. Where jarring on a smaller scale is desired, sheets can be made of a size to be easily handled by one man. For this purpose frames 9 feet by 4½ feet are convenient and will answer for moderately sized peach, plum, and cherry trees.

Another catcher which is in common use, especially by the plum growers of western New York (see figure 5), is a two-wheeled cart upon which is mounted a canvas covering arranged in the form of an inverted umbrella. There is a narrow opening at the front to receive the trunk of the tree. When the catcher is in position, the trunk of the tree is given a sharp blow. This causes the beetles to drop to the canvas, from which they are swept into the tin receptacle, or "hopper," hanging under the center of the cart directly beneath an opening in the canvas. Some operators place kerosene in the "hopper" to destroy the insects as soon as they fall into it. Others have chestnut roasters placed at the end of the rows, in which the insects and rubbish collected in the "hopper" are finally roasted.

Although the operations just described are somewhat laborious and expensive, many orchardists have demonstrated that the outlay in time and money thus invested will bring profitable returns. Some interesting figures concerning the cost of and results from this work as practiced in a Georgia orchard were obtained by Messrs. W. M. Scott and W. F. Fiske during the season of 1900 and published in Bulletin No. 31, new series, of this Bureau. Some 200,000 bearing peach and 50,000 bearing plum trees were jarred about 16 times during the period from April 18 to June 1. Eleven gangs, or 55 hands, with 5 attendants, were engaged in the work. The total cost for labor and repairs was placed at about $1,000. The number of curculios caught during the season was estimated at about 137,000. On the assumption that one-half of these were females, each capable of laying 200 eggs, it will be seen that 13,700,000 eggs, less those deposited by the beetles before capture, were kept from the fruit. The amount of curculio damage in this orchard for the season was

placed at about 4 per cent of the crop. In an adjacent orchard of 130,000 peach trees not jarred curculio injury was placed at 40 per cent of the crop.

Poisons.—It has long been known that the beetles feed on the plants upon which they lay their eggs, and numerous careful experiments have shown that they may be poisoned by thoroughly spraying the trees with arsenicals. The results of such work, however, appear to vary somewhat, depending on the relative abundance of the beetles during a given season. Many orchardists have adopted the practice of spraying for the curculio in preference to jarring, on account of the labor involved in the latter and the frequency with which the work must be repeated to make it effective. Professor Crandall, in Illinois,[a] has shown that curculio injury to apples may be reduced some 20 to 40 per cent by a reasonable number of poison applications. The results of persistent spraying by orchardists in western New York are set forth by Professor Slingerland in Bulletin No. 235 of the Cornell Experiment Station. It is there stated that the growers are almost all in favor of spraying for the curculio, especially upon plums and cherries. The exact value of arsenicals in controlling the curculio on peach has apparently not yet been determined, though there are numerous growers who spray their peach trees every year and report good results. The foliage of peach is likely to be injured, however, by repeated applications of arsenical sprays, and the grower using these sprays for the first time should proceed with caution. In localities where it has been established that no injury results from their use, they are to be recommended. Other stone fruits, while liable to foliage injury from repeated applications of arsenicals, are apparently not so sensitive as is the peach, but care should be taken at all times that the poison be used as recommended below. Apple and pear are rarely, if ever, injured by the proper use of arsenicals. Of the poisons available, such as Paris green, "green arsenoid," and arsenate of lead, the latter is least likely to be injurious and should be used where stone fruits are to be treated. Liability to injury from arsenical poisons will be greatly reduced by adding to each 50 gallons of the spray the milk of lime made by slacking 2 or 3 pounds of good stone lime. Where Bordeaux mixture is employed against scab and other fungous diseases, the arsenical may be used in the fungicide, and the milk of lime is then unnecessary. To be reasonably effective in killing the beetles, arsenate of lead should be used at the rate of 2 pounds to 50 gallons of water. Paris green or green arsenoid should not, on stone fruits, be used stronger than 1 pound to 150 or 200 gallons of water. On pome fruits a somewhat greater strength may be used without danger of injury to the foliage.

[a] Bul. 98, Ill. Agric. Exp. Sta., p. 553.

Since the period of feeding and egg laying of the curculio extends over several weeks from its emergence in spring, several applications of poison are necessary. The first application should be made as soon as the blossoms have fallen, and three or four subsequent applications should be made at intervals of eight to ten days. In the case of apple the usual two applications for the codling moth or canker-worms—just after petals fall and again within a week or ten days—will answer for the first two applications against the curculio. In spraying for the curculio, too much stress can not be laid on the importance of making the applications as thorough as possible. The effort should be made to cover every leaf, twig, and fruit.

Cultivation.—Another vulnerable period in the life of the insect is that when the larva has reached its growth and has passed into the soil. At a distance varying from one-half to 2 inches from the surface the larva makes a small earthen cell in which to undergo its transformation to the pupa, and, later, to the adult beetle. While these changes are taking place the insect is in a perfectly helpless condition, and the stirring of the soil with a cultivator at this period will doubtless break up the cells, causing the death of many of the delicate pupæ. Since cultivation is a necessary feature of orchard practice, effort should be made to carry on a part of it at a period when a majority of the insects are easily destroyed. Careful observations show that in the vicinity of Washington, D. C., and southward the larvæ begin to enter the soil about six weeks from the time fruit trees are in full bloom. In Illinois, according to Professor Crandall, about two months elapse between the period of full bloom and the date at which larvæ begin to enter the soil. Since the period of maximum egg laying covers from four to five weeks, there is a like period when the pupæ are in the soil in maximum numbers. Cultivations to destroy the curculio should therefore begin six or eight weeks, according to latitude, from the time of full bloom of the trees and should be continued for four or five weeks. Such work could be readily arranged for as part of the regular cultivation given the orchard.

Gathering fallen fruit.—The number of curculios can be greatly reduced by picking up and destroying the fallen fruit infested with larvæ. Much of the infested fruit falls to the ground several days before the larva is full grown and ready to leave it. If this be gathered and burned, at intervals of three or four days, it will result in greatly lessening the number of beetles to attack the fruit in the fall and following spring.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *April 14, 1906.*

[Cir. 73]

O